

西藏东部牧民对藏药植物山莨菪的传统利用及环境适应意义*

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摘要: 野生植物资源及相关传统知识是传统人类社会应对自然灾害的重要基础。在西藏东部地区, 传统藏药植物山莨菪 (*Anisodus tanguticus*) 是当地牧民防御冬季低温灾害对牲畜造成伤害的一种重要的植物资源。本文采用半结构访谈法和参与式观察法, 对 7 个村 13 个关键信息员, 以及 2 个村以畜牧为主的牧户进行了访谈调查。对牧民秋季收割山莨菪地上枯枝部分以备冬季饲喂家畜作为防御冬季雪灾和冷害等传统知识和实践进行了记载。针对山莨菪含剧毒的问题, 牧民采取严格控制采收时间和饲喂对象的方法来解决。当地社区积累了关于山莨菪生长习性、用法、功效等方面较为完整的知识, 并通过对其权属进行民间界定, 实现了对资源的良性管理。这一案例表明: 人类在与自然长期互动的过程中所产生和积累的传统知识能够为其防御自然灾害, 降低气候风险起关键性作用。

关键词: 传统知识; 牧民; 青藏高原; 饲料植物; 山莨菪

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Indigenous Knowledge and Use of *Anisodus tanguticus* in Pastoral Communities of Eastern Tibet, China, and Its Implications for Local Adaptation

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Abstract: Wild plant resources and related indigenous knowledge often play important role in facilitating human societies to mitigate the impacts of natural disasters and climate variability. We present a case study of using a traditional herb, *Anisodus tanguticus*, in a novel way by local pastoralists on the eastern Tibetan Plateau in coping with extreme winter events. Interviews of 13 key informants were carried out in seven villages, and in-depth household surveys were conducted in two villages covering all the pastoral-dependent households. Participatory observation has also been employed. We found that local herders applying dried above ground part of *A. tanguticus* as a supplementary feed to livestock in winter, with the purpose of helping animals to overcome cold events and snow disasters. Ac-

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according to local communities, time of harvesting and type of animal to be fed are key factors of using this toxic plant. Local communities have accumulated a rich repository of knowledge about *A. tanguticus*, including its habitat, life history, uses, and health enhancing effects. They developed an informal tenure system and benign management practices on this plant. This paper demonstrates that indigenous knowledge evolved from long-term human-nature interaction is important in preventing climate induced damages and lowering the risk aroused from climate uncertainties.

Key words: Indigenous knowledge; Pastoralists; Tibetan Plateau; Fodder plants; *Anisodus tanguticus*

In recent decades, concerns have been raised globally regarding the need for a better understanding of climate change and its impacts on physical and socioeconomic systems. This concern has led to a focus on adaptation research (Schiper *et al.*, 2009). As the magnitude and impacts of climate change increase (IPCC, 2007), societies and government agencies at various levels, from international to national and local scales, have engaged in diverse actions aimed at climate change adaptation and mitigation. Climate change adaption, as defined by the Intergovernmental Panel on Climate Change (IPCC) (2007), refers to activity aimed at avoiding or reducing adverse impacts in relation to current and projected climate change, while grasping emerging opportunities (IPCC, 2007).

The Tibetan Plateau, referred to as the “roof of the world”, is subject to extremely harsh environmental conditions and is also one of the most sensitive regions in the world to climate change (Zheng *et al.*, 2002). Average air temperatures have increased by 0.16 °C per decade, which is higher than the increase in the Northern Hemisphere as a whole (Liu and Chen, 2000). The frequency of extreme events such as snow disasters has shown a rising trend in some regions of the plateau (Zhang *et al.*, 2004; Guo *et al.*, 2010). This plateau is also home to 10 million pastoralists (Long, 2003) whose livelihoods are dependent on its grasslands. Climate change has been exerting considerable impacts on pastoral production in the region. It is reducing grassland productivity (Klein *et al.*, 2007; Yu *et al.*, 2010), and attenuating livestock production, incrementally (Zhang and Li, 2009; Fu *et al.*, 2012). It also directly causes livestock loss through extreme events such as

snow disasters (Wu and Yan, 2002; Miller, 2000).

To reduce climate-induced risks, adaptation policies for the Tibetan Plateau have been launched at both the national and provincial levels, focusing on environmental conservation and socioeconomic development (NDRC, 2007; DRCQ, 2008; DRC TAR, 2009). However, little is known about the effects and efficiency of the implemented policies. Moreover, there is widespread awareness within the academy that local communities, with their indigenous knowledge, have the capacity and mechanisms to deal with a changing climate (Salick and Ross, 2009; Green and Raygorodetsky, 2010). Tibetan pastoralists, for thousands years, have demonstrated great capacity to adapt to local environmental variability by using their comprehensive indigenous knowledge about local climate, biodiversity, etc (Goldstein and Beall, 1990; Wu, 2004). Based on the knowledge, pastoralists manage grasslands and livestock through flexible institutional arrangements. Seasonal transhumance and rotational grazing has been used to deal with climate-induced variations of grassland productivity (Miller, 2002; Wu, 2004). Herd composition is diversified according to vegetation type to minimize livestock loss in cold winters (Miller, 2002). Various fodder plants have been stored to enhance livestock survive rate during winter and snow disasters (Fu *et al.*, 2012).

On Bangda rangeland of eastern Tibet, China, *Anisodus tanguticus* (Maxim) Pascher, has been used by Tibetan pastoralists as a forage supplement in winter to combat snow disasters which often cause substantial livestock loss. Local communities have developed a rich repository of knowledge about *A. tanguticus*, on its habitat, life history, harvesting, usa-

ges, effects etc. Intriguingly, however, *A. tanguticus* is also reported as a toxic plant (Ma *et al.*, 2015). Despite of its popularity as herbal medicine for human, there is no existing record of the application of this poisonous plant for livestock health.

A. tanguticus is a perennial herbal species in Solanaceae family. It is endemic to the Tibetan Plateau, and is thought to have originated in the south-east of the plateau and subsequently to have expanded its distribution to the interior part of the plateau (Tu *et al.*, 2010). It usually grows on sunny grassy slopes, along roadsides, and near settlements at elevations ranging from 2 000 to 4 400 m (Yang, 1991; FoC, 2014). It has been used as medicinal plant in both Tibetan Ethnomedicine (Ma *et al.*, 2015) and traditional Chinese medicine (Lee *et al.*, 2013). According to a Tibetan tale, *A. tanguticus* was generated from the poison of Brahma, the Hindu God of Creation (Mao *et al.*, 2012). Traditionally, the roots and seeds are mainly used for relieving pain such as toothache and stomachache, and also for killing parasites and treating skin wounds caused by viral infections (Yang, 1991; Lee *et al.*, 2013).

In this study, we aimed to exam the role of indigenous knowledge in adaptation to environmental uncertainties and extreme climate events, through investigation of the undocumented traditional knowledge and use of *A. tanguticus* by Tibetan pastoralists in the Bangda rangeland, evaluation of its importance for local communities, and discussion of its implications for local communities to adapt to local climate variability.

1 Methods

1.1 Study site

Bangda is a typical Tibetan highland pastoral area. It is located in the upstream watershed of the Salween River at an average elevation of 4 300 m a.s.l. This area is covered mostly by the dominated *Kobresia* sedges, accompanied by genera such as *Carex* and *Polygonum* (Sheehy *et al.*, 2006). Cold temperatures characterize the climate here, with the frequent occurrence of extreme climate events such as

snow disasters. The annual average temperature is around 4–6 °C (Fan, 2008), and annual precipitation is around 500–600 mm (Qi *et al.*, 2013). Snow disasters are common in this region, occurring every 3–5 years according to metrological records (Zhang, 2013). They usually occur from September to April, and are especially frequent from February to April, which may cause substantial livestock loss.

Bangda comprises four townships under the administration of Baxoi County in the Tibetan Autonomous Region of China. The livelihoods of the communities in these townships are mainly dependent on grazing-based animal husbandry. Our research focused on one township, *i. e.* Yiqing Township, where *A. tanguticus* is abundant (Fig. 1). Yiqing Township comprises a total area of 900 km² with 2 500 population. There are 36 villages within Yiqing Township with the number of households ranging from two to 21. Yaks are the main livestock raised by local people, along with sheep, goats, and horses. Grazing activities are seasonally transhumant. Local pastoralists generally stay in winter pastures for eight months, extending from September to April, and then spend 2 months (usually June and July) in summer pastures at higher elevations. During the remaining part of the year, they move to spring and autumn pastures (Fu *et al.*, 2012).

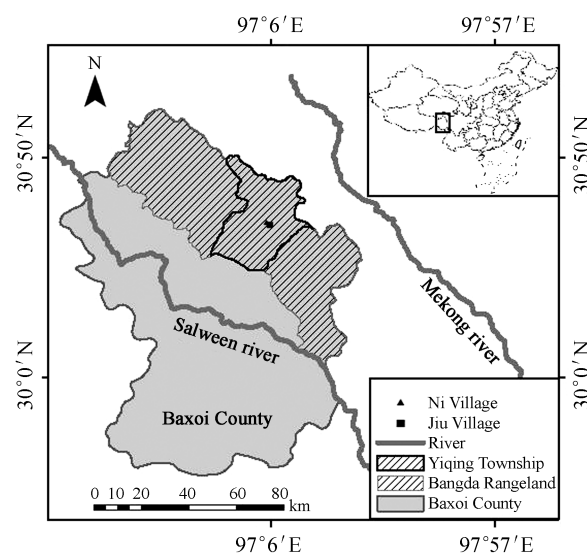


Fig. 1 Location of the study area

1.2 Data collection and analysis

Data were collected during four field trips carried out during both summers and winters from 2009 to 2010. Each field trip was for a period of about 1–2 months. The methods employed for this study were semi-structured interviews and participatory observation. All interviews with villagers were conducted with the help of local interpreters, and all participants gave their informed consent to be interviewed.

There are two aspects in our field researches: investigation of local knowledge of *A. tanguticus*, and evaluation of the importance of *A. tanguticus* for local communities. Key interview questions have been listed in Table 1. To obtain local knowledge of *A. tanguticus*, 13 elders (4 females and 9 males) from 7 out of the 36 villages in Yiqing Township were interviewed. They were chosen as key informants because they met both of the following criteria: they were over 60 years old, and they had rich herding experience and knowledge regarding *A. tanguticus*. Participatory observation was conducted throughout the field research to cross check and consolidate the information acquired through interviews.

To assess the importance of *A. tanguticus*, household interviews have been carried out in two communities of Yiqing Township: Ni and Jiu villages (Fig. 1). The two villages are adjacent to each other and have similar environmental conditions. Their winter and

summer pastures are located, respectively, at 4 300 and 4 500 m a.s.l. There are 20 household, 101 people, and 2 262 livestock (sheep unit) in Ni village, while there are 11 household, 63 people, and 1 892 livestock (sheep unit) in Jiu village. Incomes in this area are derived from livestock products, trucking, harvesting of *Cordyceps sinensis*, known locally as yartsa gunbu, which is the Tibetan word for a winter worm summer grass, provisions, and wage labor. Of these, livestock products account for more than half of total incomes (Fu *et al.*, 2012).

Households whose income from husbandry exceeded 50% of their total incomes were interviewed at least once. In total, 11 households in Ni and 8 households in Jiu were interviewed. Household heads (whose ages ranged from 30 to 74 years), of both genders, were interviewed. The underlying assumption was that they possessed the most information. Both female and male household heads were interviewed at the same time, wherever possible, to obtain more information, with the following exceptions: three households having only female heads and one household with only a male head.

Data were analyzed by pooling together the responses of all the individuals who were interviewed. Voucher specimens of *A. tanguticus* were collected in 2009 and identified at the Kunming Institute of Botany, at the Chinese Academy of Science.

Table 1 List of key interview questions

Interview questions in relation to local knowledge of <i>A. tanguticus</i> 1. Where does <i>A. tanguticus</i> usually grows, is there anyone plant it? 2. What is the life history of <i>A. tanguticus</i>? 3. When and how to harvest and process <i>A. tanguticus</i> and why? 4. What are the usages and effects of <i>A. tanguticus</i>? 5. How to use <i>A. tanguticus</i> to feed livestock, when, and to what kinds of animals, and why? 6. How to decide the quantity to be feed to certain animal, and why? 7. Where have you learned the knowledge about <i>A. tanguticus</i>?
Interview questions in relation to the importance of <i>A. tanguticus</i> 1. Do you apply <i>A. tanguticus</i> to your livestock, and when and how? 2. For combating snow disasters, do you think <i>A. tanguticus</i> is more important, equally important, less important, or not important in comparison to planted fodder and purchased forages?

2 Results

The use of *A. tanguticus* as a special livestock feed is prevalent across Bangda rangeland and its adjacent areas. Our findings indicated that local pastoralists have developed a rich knowledge repository of *A. tanguticus* as the result of their long-term interactions with their local environment. Elders aged over 70 years confirmed that their knowledge regarding the use of this plant had been passed down by their ancestors over generations. Pastoralists' knowledge of *A. tanguticus* included its living habitat, life history, methods of use, and effects on livestock health.

2.1 Habitat and life history

According to pastoralists, *A. tanguticus* generally grows near their winter houses. It is then deliberately enclosed within each household's backyard where forage crops are planted (Fig. 2A–B). Recognized

by local people and confirmed by botanical studies as a perennial, this plant germinates in April or May and flowers in June. The seeds mature in August, and the aboveground parts turn a yellow color in late August or September. This is the critical and right harvest time for its use as a special livestock feed during winter and snow disasters.

2.2 Methods of traditional forage use

Pastoralists often harvest *A. tanguticus* together with planted forage crops. The aboveground parts are sundried and stored separately for subsequent use (Fig. 2C–D). During cold winter days and snow disasters, usually between September and April, this forms a supplementary feed for livestock, in addition to planted and purchased forage crops. A household member, usually the female head, cuts the dried *A. tanguticus* into small pieces and allocates these on



Fig. 2 A. Flower of *A. tanguticus*; B. *A. tanguticus* grows at local pastoralists' backyard where forage crops are planted; C. The aboveground parts of *A. tanguticus* are collected and sundried in autumn; D. *A. tanguticus* was prepared by a pastoral household to feed their livestock in winter

separate plates to feed to yaks, sheep, and goats. Twice daily feeding is preferred if the amount of stored *A. tanguticus* is sufficient. The amount of feed differs according to weather conditions and the physical strength of each animal. During colder days, larger amounts are required. The weaker animals and milking yaks are given more feed. However, all the pastoralists know that horses should not be fed this plant or else they will be poisoned.

2.3 Effects upon livestock

Pastoralists in the Bangda rangeland are aware that *A. tanguticus* is toxic. However, the degree of its toxicity varies throughout its life history. It is not harvested during the growing season as it is used for livestock. Only the aboveground parts of the plant are used when they turn yellow. There are three major livestock health effects of *A. tanguticus*, described by pastoralists, as shown in Table 2. First, it warms the body of an animal. According to locals, this effect is equivalent to a person's consumption of alcohol when feeling cold. Second, it improves the health of livestock, making them stronger and enhancing their capacity to combat disease. Third, it improves their physical strength and combats weight loss. Livestock usually lose weight during the winter/spring and snow disasters as a result of grass shortages. However, according to local people, those animals that are fed *A. tanguticus* will lose less weight.

Table 2 *A. tanguticus* effects on livestock health reported by pastoral households in Ni and Jiu villages ($n=19$)

Medical effects on livestock health	Total number of times reported in Ni and Jiu villages
Warms up the animal's body	19
Improves general health conditions	11
Prevents weight reduction during winter/spring/snow disasters	9

2.4 Importance of *A. tanguticus* to local pastoralists

A. tanguticus has long been considered important by local pastoralists. We compared its importance against other forages in terms of combating snow disasters. Based on our interviews in Ni and Jiu villages,

14 out of 19 households reported that *A. tanguticus* was equal in importance to planted and purchased forage crops (64% and 88%, respectively, in Ni and Jiu villages). No one reports it is more important than other forages, and only four out of 19 households considered *A. tanguticus* to be less important than other forages (Table 3).

Table 3 Importance of *A. tanguticus* compared with planted and purchased forages in Ni and Jiu villages

Total report number	More important	Equally important	Less important	Not important
19	0	14	4	1

An interesting observation was that every household defined their ownership of *A. tanguticus*. *A. tanguticus* was fenced off as private property within the backyard of each household. This focus on ownership indirectly reflects the importance of this particular plant for these communities. Moreover, this practice can be traced back prior to the 1950s when forage plantation was uncommon. While fences were not used to demarcate the boundaries of the backyards, each household's ownership of *A. tanguticus* was still clear, as this was based, distally, on the distance of the plant's location to that of a house.

3 Discussions

3.1 *A. tanguticus*: important fodder plant for sustaining alpine pastoral production systems

Based on our results, *A. tanguticus* is an important wild plant resource as supplement livestock feed in winter. It plays a positive role in preventing livestock loss in alpine pastoral systems during winter and early spring. *A. tanguticus*, as a fodder plant, not only assists livestock to combat snow disasters, but also enhances the survival rate. According to phytochemical and pharmaceutical researches, *A. tanguticus* has multiple medicinal functions, including relieving pain, anti-spasticity, anti-inflammation, as analeptic, etc. (Yang, 1991, Lee *et al.*, 2013). These effects may contribute to livestock health, especially for those weaker ones surviving through cold winters.

There is evidence that four main alkaloids extracted from *A. tanguticus* contribute to its medicinal effects. These are: anisodamine, scopolamine, anisodine, and hyoscyamine (Lee *et al.*, 2013). The curative mechanisms and effects of these four alkaloids have been relatively well studied in relation to human health. They have similar pharmaceutical functions affecting the parasympathetic nervous system, but differ in their potencies and efficacies (Lee *et al.*, 2013). Based on their pharmaceutical mechanisms in relation to human diseases, these alkaloids are also used to treat livestock diseases. For example, anisodamine has been applied in the prevention of livestock mortality caused by Shiga toxins (Hammerschmidt, 2001). Scopolamine has been used to treat livestock diarrhea, and hyoscyamine has been employed in the treatment of livestock poisoning (Li, 1993; Hua and Zhou, 1998).

Three major effects of *A. tanguticus* related to livestock health have been described by local pastoralists in Bangda rangeland. We suggest that the above-mentioned four alkaloids may contribute to these effects. Specifically, the warming up effect on livestock, described by pastoralists, may be causally related to these alkaloids, which regulate body temperature through their influence on the autonomic nerve system. This has been reported in clinical case studies (Li, 1986; Lee *et al.*, 2013). These alkaloids have also been found to play a role in improving the general health status of livestock by regulating their immune systems (Li, 1986; Li, 1993). These medical findings appear to endorse indigenous knowledge of pastoral communities in this region regarding the effects of *A. tanguticus*. The third effect of weight retention may also be related to the above-mentioned functions.

3.2 Traditional knowledge of pastoralists on wise use of local biodiversity: avoiding toxicity of *A. tanguticus*

We found that local communities had a rich repository of biological and ecological knowledge regarding *A. tanguticus*. They had developed innovative

uses for this plant as a dietary supplement for livestock in winter. They effectively avoid the toxicity of *A. tanguticus* by regulating plant harvest time and its recipients, which has not been previously reported. It manifests the deep understanding of local biological resources by pastoralists.

A. tanguticus is evidently poisonous. The alkaloids it contains, particularly, scopolamine and hyoscyamine, have proven extremely toxic for mammals (Caligiani *et al.*, 2011; Mulder *et al.*, 2014). Because of this concern, European law strictly regulates permissible quantities of *Datura stramonium* seeds (which have similar alkaloids to those found in *A. tanguticus*) introduced in animal feeds. This quantity is less than one *Datura stramonium* seed to a million crop seeds (Caligiani *et al.*, 2011).

The indigenous knowledge revealed by our study has indicated that the timing of the harvest of this plant is critical when using it as a dietary supplement. Only those materials harvested during the autumn, when the parts of the plant aboveground turn yellow, can be used for this purpose. It has been experimentally proved that the content of these alkaloids in the aboveground part of *A. tanguticus* is highest during the flowering period and lowest during the withering period (Zhang and Wang, 2002). Thus, we postulate that their effect is dosage-dependent, which has been confirmed by several drug studies of the Solanaceae family (Jürgen, 1998; Everett and Gabra, 2014). While high levels of alkaloid content have a fatal impact on livestock, low levels may enable them to cope in a harsh winter environment. However, Bangda pastoralists proscribe the use of *A. tanguticus* to feed horses, regardless of any conditions. The poisonous effect of these alkaloids on horses has also been reported in South Africa (Naudé *et al.*, 2005).

3.3 A sophisticated practice of pastoralists on management of *A. tanguticus* on the Tibetan Plateau

It can be inferred by our study, that *A. tanguticus* has been managed by local pastoralists in a benign way through defining ownership on this plant.

A. tanguticus, as private property, has been fenced into each household's backyards. There is reasonable incentive for pastoralists to manage it well. The abundant distribution of *A. tanguticus* around winter settlements in the Bangda area is an evidence for this benign management.

In addition, there are some unintentional pastoral practices which may contribute to the abundance of *A. tanguticus* around pastoralists' winter settlements. First, seed germination of *A. tanguticus* could be facilitated through livestock trampling. *A. tanguticus* mainly reproduces through seeds (Duan *et al.*, 2007), which is a slow process under natural conditions (He and Jia, 2009). An experiment carried out by He and Jia (2009) showed that the germination rate was considerably improved by seed scarification. After feeding, leftover seeds of *A. tanguticus* that are not consumed by livestock are dispersed in a household's backyard. Livestock pens, used during the winter (from September to April), are also located in the backyard. Seeds thus have a better chance of germinating as a result of mechanical scarification caused by livestock trampling in the pens. Second, *A. tanguticus* is in all probability a nitrophilous plant. Such plants are readily found near settlements where animal manure is present in large quantities (Yang, 1991). Winter backyards, therefore, provide sufficient nutrients for its growth. Third, vegetative propagation of *A. tanguticus* is enhanced by ploughing carried out in conjunction with forage plantation activities. During this process, roots of *A. tanguticus* with shoots get broken up and dispersed, leading to the growth of new plants. For their tissue culture research, He *et al.* (2011) employed the root-shoot method for propagating *A. tanguticus*. Last, using the withered aboveground parts of *A. tanguticus* for animal feed entails a low degree of adverse impacts on its population dynamics compared with harvesting its roots for medicinal use.

3.4 Important knowledge of Bangda pastoralists for local adaptation to climate extremes

Great fluctuation of livestock production is one

of the major problems for the pastoral production system on the Tibetan plateau. It also influences local livelihoods significantly. Seasonal and inter-annual variability of grassland primary productions led to considerable variation of livestock secondary productions. Highly uncertainty of the occurrences of extreme climate events may cause substantial livestock loss. In addition, the Tibetan Plateau is experiencing unprecedented climate change. The Intergovernmental Panel on Climate Change (IPCC) projects that by 2065, temperatures in this region will increase by more than 3 °C, and the uncertainty of precipitation and extreme events such as snow disasters will rise (IPCC, 2013). How to mitigate adverse impacts of these problems have been the key challenges for grazing based animal husbandry on the Tibetan plateau. The use of *A. tanguticus* by Bangda pastoralists provides a good example of adaptive management by using local biodiversity and related indigenous knowledge. It illustrates that indigenous knowledge is one of the critical factors to sustain local productions systems under climate variability, and it is also important for local adaptation to environmental extremes.

4 Conclusions

Having lived in extremely harsh environmental conditions for thousands of years, Tibetan pastoralists, with their profound indigenous knowledge, have developed various approaches for adapting to environmental uncertainties. The knowledge provided by Bangda pastoralists regarding the use of the widely known toxic species, *A. tanguticus*, for safeguarding livestock health during inclement weather is inspiring. It demonstrates the wisdom of converting a poisonous item into a medicine by using the right parts at the right time. Moreover, it reveals that indigenous knowledge and local biodiversity can support the sustainability of local production systems under a highly variable climate, and it is also vital for local adaptation to environmental variability. However, the phytochemical and pharmaceutical mechanisms behind this knowledge need further exploration. With

the consent of local communities, veterinary and bioprospecting research should therefore be conducted to further explore these.

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References:

- 毛继祖 (Mao JZ), 林鹏程 (Lin PC), 吉守详 (Ji SX) 等译, 2012. 晶珠本草-藏医药经典 (晶珠本草) [M]. 上海: 上海科学技术出版社, 130—131
- 杨永昌主编 (Yang YC ed.), 1991. 藏药志. [M] 青海: 青海人民出版社, 142—143
- Caligiani A, Palla G, Bonzanini F *et al.*, 2011. A validated GC-MS method for the detection of tropane alkaloids in buckwheat (*Fagopyron esculentum* L.) fruits, flours and commercial foods [J]. *Food Chemistry*, **127**: 204—209
- Development and Reform Commission of Qinghai Province (DRCQ 青海省发展与改革委员会), 2008. China's policies and actions on climate change: The provincial plan of Qinghai Province. Xinjing: DRCQ
- Development and Reform Commission of the Tibetan Autonomous Region (DRC TAR 西藏自治区发展与改革委员会), 2009. China's policies and actions on climate change: The prefectural plan of Tibetan Autonomous Region. Lhasa: DRC TAR
- Duan YW (段元文), Zhang TF (张廷峰), Liu JQ (刘建全), 2007. Pollination biology of *Anisodus tanguticus* (Solanaceae) [J]. *Biodiversity Science* (生物多样性), **15** (6): 584—591
- Everett N, Gabra M, 2014. The pharmacology of medieval sedatives: The “GreatRest” of the Antidotarium Nicolai [J]. *Journal of Ethnopharmacology*, **155**: 443—449
- Fan HF (樊红芳), 2008. The current climate characteristics and topographic climate effect on Tibetan Plateau. PhD thesis. Lan zhou University, Geography department
- Flora of China (FoC), 2014. http://www.efloras.org/florataxon.aspx?flora_id=2&taxon_id=200020508 [OL].
- Fu Y, Grumbine RE, Wilkes A *et al.*, 2012. Climate change adaptation among Tibetan pastoralists: challenges in enhancing local adaptation through policy support [J]. *Environmental Management*, **50**: 607—621
- Goldstein M, Beall C, 1990. *Nomads of Western Tibet: the Survival of a Way of Life* [M]. Berkeley: University of California Press
- Green D, Raygorodetsky G, 2010. Indigenous knowledge of a changing climate [J]. *Climatic Change*, **100** (2): 239—242
- Guo XN (郭晓宁), Li L (李林), Liu CH (刘彩红) *et al.*, 2010. Spatio-temporal distribution of snow disaster in Qinghai Plateau during 1961–2008 [J]. *Advances in Climate Change Research* (气候变化研究进展), **6** (5): 332—337
- Hammerschmidt DE, 2001. This month in J Lab Clin Med: issue highlights for June 2001 [J]. *The Journal of Laboratory and Clinical Medicine*, **137**: 375—378
- He T, Jia JF, 2009. Breaking dormancy in seeds of *Anisodus tanguticus*: an endangered medicinal herb of high altitude in the Qinghai-Tibet Plateau [J]. *Seed Science and Technology*, **37** (1): 229—231
- He T, Wang HT, Yang LN *et al.*, 2011. Micropropagation of *Anisodus tanguticus* and assessment of genetic stability of regenerated plants using inter simple sequence repeat (ISSR) marker [J]. *Journal of Medicinal Plants Research*, **5** (25): 5993—5998
- Hua JL (华进联), Zhou HC (周宏超), 1998. Effects of scopolia drugs on veterinary clinic applications [J]. *Journal of Traditional Chinese Veterinary Medicine* (中兽医医药杂志), **6**: 17—18
- Intergovernmental Panel on Climate Change (IPCC), 2007. Climate Change 2007: Synthesis Report [http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr_cn.pdf]
- Intergovernmental Panel on Climate Change (IPCC), 2013. Climate Change 2013: *The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [M]. United Kingdom and New York: Cambridge University Press 996, 1283
- Jürgen LM, 1998. Love potions and the ointment of witches: historical aspects of the nightshade alkaloids [J]. *Journal of Toxicology. Clinical Toxicology*, **36** (6): 617—627
- Klein JA, Harte J, Zhao XQ, 2007. Experimental warming, not grazing, decreases rangeland quality on the Tibetan Plateau [J]. *Ecological Application*, **17** (2): 541—557
- Lee KH, Morris-Natschke SL, Brattlie J *et al.*, 2013. Modern drug discovery from Chinese materia medica used in traditional Chinese medicine [A] // Adams JD, Lien E J ed., *Traditional Chinese Medicine: Scientific Basis for Its Use* [M]. London: The Royal Society of Chemistry, 81—134
- Li ZL (李正良), 1986. Pharmacological research of scopolia drugs [J]. *Herald of Medicine* (医药导报), **4**: 42—43
- Li GL (李光灵), 1993. Pharmacological effects of scopolia drugs and their application in veterinary clinic [J]. *Chinese Journal of Traditional Veterinary Science* (中兽医学杂志), **2**: 37—40
- Liu XD, Chen BD, 2000. Climatic warming in the Tibetan Plateau during recent decades [J]. *International Journal of Climatology*, **20** (14): 1729—1742
- Long RJ, 2003. Alpine rangeland ecosystems and their management in

- the Qinghai-Tibetan plateau [A]// Gerald W, Han JL, Long RJ ed., *The Yak* [M]. Bangkok: Regional Office for Asia and the Pacific Food and Agriculture Organization of the United Nations, RAP publication, 359—386
- Ma L, Gu R, Tang L *et al.*, 2015. Important poisonous plants in Tibetan Ethnomedicine [J]. *Toxins*, **7**: 138—155
- Miller DJ, 2000. Tough times for Tibetan nomads in Western China: Snowstorms, settling down, fences and the demise of Traditional nomadic pastoralism [J]. *Nomadic Peoples*, **4** (1): 83—109
- Miller DJ, 2002. The importance of China's nomads [J]. *Rangelands*, **24** (1): 22—24
- Mulder PPJ, Holst CV, Nivarlet N *et al.*, 2014. Intra- and interlaboratory validation of a dipstick immunoassay for the detection of tropane alkaloids hyoscyamine and scopolamine in animal feed [J]. *Food Additives and Contaminants A*, **31** (7): 1165—1176
- National Development and Reform Commission (NDRC), 2007. *China's National Climate Change Programme* [M]. Beijing: NDRC
- Naudé TW, Gerber R, Smith RJ *et al.*, 2005. Datura contamination of hay as the suspected cause of an extensive outbreak of impaction colic in horses [J]. *Journal of the South African Veterinary Association*, **76**: 107—112
- Qi WW (齐文文), Zhang BP (张百平), Pang Y (庞宇) *et al.*, 2013. TRMM-data-based spatial and seasonal patterns of precipitation in the Qinghai-Tibet plateau [J]. *Scientia Geographica Sinica* (地理科学), **33** (8): 999—1005
- Salick J, Ross N, 2009. Traditional peoples and climate change [J]. *Global Environmental Change*, **19** (2): 137—139
- Schipper ELF, Burton I, 2009. Understanding adaptation: Origins, concepts, practice and policy [A]// Schipper ELF, Burton I eds., *Adaptation to Climate Change* [M]. London: Earthscan, 1—8
- Sheehy DP, Miller D, Johnson AD, 2006. Transformation of traditional pastoral livestock systems on the Tibetan steppe [J]. *Sécheresse*, **17** (1-2): 142—151
- Tu TY, Volis S, Dillon MO *et al.*, 2010. Dispersals of Hyoscyameae and Mandragoreae (Solanaceae) from the New World to Eurasia in the early Miocene and their biogeographic diversification within Eurasia [J]. *Molecular Phylogenetics and Evolution*, **57**: 1226—1237
- Wu N, Yan ZL, 2002. Climate variability and social vulnerability on the Tibetan Plateau: dilemmas on the road to pastoral reform [J]. *Erdkunde*, **56** (1): 2—14
- Wu N (吴宁), 2004. Traditional utilization of rangelands in western Sichuan: disputation on pastoral nomadism [J]. *Journal of Mountain Science* (山地科学学报), **22** (6): 641—647
- Yu HY, Luedelinge E, Xu JC, 2010. Winter and spring warming result in delayed spring phenology on the Tibetan Plateau [J]. *PNAS*, **107** (51): 22151—22156
- Zhang XF (张晓峰), Wang H (王环), 2002. The variation of the contents of four tropane alkaloids in *Anisodus tanguticus* [J]. *Acta Bot Boreal-Occident Sin* (西北植物学报), **22** (3): 630—634
- Zhang YS, Li T, Wang B, 2004. Decadal change of the spring snow depth over the Tibetan Plateau: the associated circulation and influence on the East Asian summer monsoon [J]. *Journal of Climate*, **17** (14): 2780—2793
- Zhang J, Li YJ, 2009. Views of livestock herders and others concerning the impact of climate change on the Yangtze source region [A]// Farrington JD ed., *Impacts of Climate Change on the Yangtze Source Region and Adjacent Areas, Qinghai-Tibet Plateau, China* [M]. Beijing: China Meteorological Press, 113—173
- Zhang TT (张涛涛), 2013. Trends and mechanisms of snow disasters on the Tibetan Plateau in the context of global climate change. *Master thesis*. Shaanxi Normal University, Geography department
- Zheng D (郑度), Lin ZY (林振耀), Zhang XQ (张雪芹), 2002. Progress in studies of Tibetan Plateau and global environmental change [J]. *Earth Science Frontiers* (地球科学前沿), **9** (1): 95—102